Issued October 22, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—BULLETIN 116.

HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

POSSIBILITIES OF WESTERN PINES AS A SOURCE OF NAVAL STORES.

BY

H. S. BETTS,

Assistant District Forester.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

FOREST SERVICE.

HENRY S. GRAVES, *Forester.*
ALBERT F. POTTER, *Associate Forester.*
HERBERT A. SMITH, *Editor.*

BRANCH OF PRODUCTS.

MCGARVEY CLINE, *Director, Forest Products Laboratory, in Charge.*
HOWARD F. WEISS, *Assistant Director.*
H. S. BETTS, *Assistant District Forester.*

ADDITIONAL COPIES of this publication may be procured from the SUPERINTENDENT OF DOCUMENTS, Government Printing Office, Washington, D. C., at 10 cents per copy

TYPICAL WESTERN YELLOW PINE TURPENTINE AREA IN ARIZONA.

Issued October 22, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—BULLETIN 116.

HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

POSSIBILITIES OF WESTERN PINES AS A SOURCE OF NAVAL STORES.

BY

H. S. BETTS,

Assistant District Forester.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., June 19, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "The Possibilities of Western Pines as a Source of Naval Stores," by Mr. H. S. Betts, Assistant District Forester, and to recommend its publication as Bulletin 116 of the Forest Service.

Very respectfully,

Henry S. Graves, *Forester.*

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Purpose of the investigation	5
Arizona experiments on western yellow pine	5
Description of experimental areas	5
Weather conditions	7
Method of conducting experiments	8
Yields	9
Comparison of yields of dip in Arizona and Florida	9
Comparison of yields of scrape in Arizona and Florida	10
Comparison of yields of dip and scrape from black jack and yellow pine	11
Composition of dip	11
Condition of tapped trees	12
Evaporation from cups	13
Special problems investigated	13
Comparison of yields from north and south faces	14
Comparison of dip from high and low faces	14
Effect of temperature on weekly flow	15
Rate of flow during week	15
California experiments on western yellow pine	16
Description of area and method of experiment	16
Weather conditions	17
Yields	17
Composition of dip and scrape	18
Evaporation from cups	18
Colorado experiments on piñon	18
Description of area and method of experiment	18
Weather conditions	19
Yield	19
Composition of dip	20
Colorado experiments on western yellow pine	20
Description of experimental areas	20
Yields	21
Summary of results	21
Problems which confront commercial development	22

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Typical western yellow pine turpentine area in Arizona..Frontispiece.
II. Turpentined face on western yellow pine..... 8
III. Fig. 1.—Typical western yellow pine turpentine area in California. Fig. 2.—Typical western yellow pine turpentine area in Colorado..... 16
IV. Mature isolated piñon on turpentine area in Colorado..... 20

TEXT FIGURES.

FIG. 1. Location of experimental areas in Arizona..... 6
2. Comparison of flow from north and south faces..... 14
3. Relation between temperature and rate of flow of gum..... 15

POSSIBILITIES OF WESTERN PINES AS A SOURCE OF NAVAL STORES.

PURPOSE OF THE INVESTIGATION.

The constantly decreasing supply of southern yellow pine timber available for turpentine operations, and the steady demand for turpentine and rosin, suggest the utilization of western pines for the production of naval stores.

During 1911 the Forest Service conducted experiments on western yellow pine in Arizona and California,[1] and on both western yellow pine and piñon in Colorado, to determine the quantity of crude oleoresin which could be secured from these pines by the methods ordinarily employed in the turpentining of longleaf yellow pine in the Southeast. The field work was supplemented by laboratory analyses to determine the quality of the gum. The experiments in California were conducted under the supervision of C. Stowell Smith, assistant district forester.

ARIZONA EXPERIMENTS ON WESTERN YELLOW PINE.

(*Pinus ponderosa* var. *scopulorum*.)

DESCRIPTION OF EXPERIMENTAL AREAS.

The Arizona experiments were conducted on the Coconino and Tusayan National Forests, about 9 miles north of Flagstaff. Cups were hung on three different areas, chosen to represent average forest conditions, and designated A, B, and C, with 500 faces on each. These three areas combined made 28¼ acres. In addition, 100 cups were hung on another area, D, for studying certain special problems. Figure 1 shows the location, altitude, and size of each of the experimental areas. The forest consisted of a pure stand of a variety of western yellow pine, running about 7,000 board feet to the acre. The surface of the ground was rolling and scattered over it were a large number of rocks of volcanic origin, commonly known as malpais rock. There was practically no undergrowth and but few trees below 12 inches in diameter breast high. Plate I shows a typical

[1] Experiments were started on lodgepole pine, sugar pine, and Douglas fir in California. The flow of gum was so small that the work was discontinued. During the season of 1912 the experiments on western yellow pine in California will be continued. The flow from digger pine, piñon pine, and Jeffrey pine will also be determined.

stand on one of the experimental areas. The number of cups per acre varied from 37 in area A to 87 in area C. The trees were divided into two classes, "yellow pine" and "black jack," and the dip from each class collected separately. The name "black jack" is commonly used for young western yellow pine with black, deeply furrowed bark and a comparatively dense crown. Later in life the bark becomes orange and smoother, and the tree is then called "yellow pine." The period in the tree's life at which the change takes place is varia-

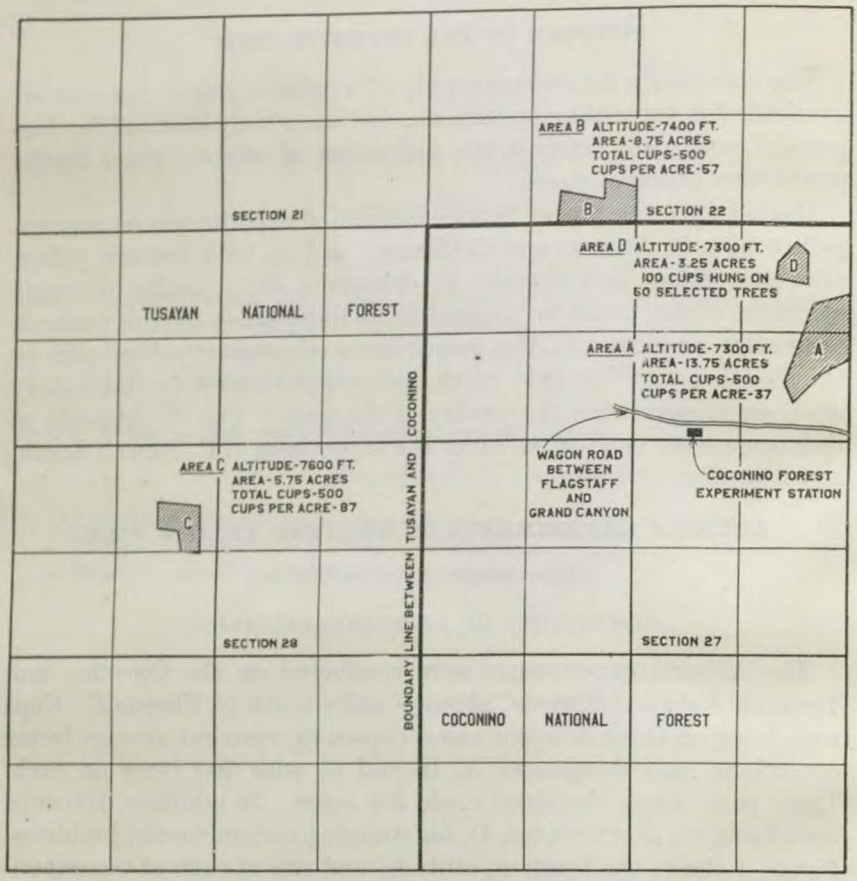


FIG. 1.—Location of experimental areas in Arizona.

ble, and it is fairly common to find black jack of considerably larger diameter than yellow pine growing close by. Table 1 shows the number and size of the tapped trees in each of the three areas, A, B, and C.

The average size of the trees in area A was greater than that in B or C. In area C the stand was denser and the trees more uniform in size than in the other two areas. Yellow pine predominated in areas A and B, while in C the stand was composed mainly of black jack.

Of the 388 yellow pines tapped, 89 had some defect, such as a fire-scarred butt, dead top, or large number of dead limbs. Of the 395 black jacks, only 15 were defective. The greatest proportion of defective trees was in area A among the large yellow pines.

TABLE 1.—*Number and size of tapped trees in the Arizona experiments; areas A, B, and C.*

Diameter, breast high.	Number of trees.								
	Area A.			Area B.			Area C.		
	Black jack.	Yellow pine.	Total.	Black jack.	Yellow pine.	Total.	Black jack.	Yellow pine.	Total.
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
12	4	1	5	7	3	10	13	2	15
13	3	.....	3	8	2	10	25	2	27
14	11	1	12	19	7	26	28	4	32
15	8	2	10	11	4	15	34	7	41
16	6	3	9	10	8	18	23	5	28
17	6	5	11	13	8	21	17	8	25
18	13	3	16	7	6	13	18	3	21
19	12	6	18	6	9	15	17	4	21
20	16	7	23	4	18	22	11	7	18
21	4	11	15	3	17	20	3	2	5
22	9	7	16	1	18	19	3	3	6
23	2	6	8	2	12	14	2	5	7
24	1	7	8	.....	14	14	4	8	12
25	1	6	7	1	12	13	3	4	7
26	1	15	16	.....	9	9	.....	5	5
27	.....	3	3	.....	5	5	.....	2	2
28	1	7	8	1	4	5	.....	.....	.....
29	1	11	12	.....	4	4	.....	1	1
30	2	6	8	.....	4	4	.....	1	1
31	.....	7	7	.....	3	3	.....	2	2
32	.....	5	5	.....	3	3	.....	.....	.....
33	.....	4	4	.....	.....	.....	.....	1	1
34	.....	3	3	.....	.....	.....	.....	.....	.....
35	.....	3	3	.....	.....	.....	.....	.....	.....
36	.....	4	4	.....	1	1	.....	.....	.....
37	.....	3	3	.....	.....	.....	.....	1	1
38	.....	1	1	.....	.....	.....	.....	.....	.....
39	.....	1	1	.....	.....	.....	.....	.....	.....
40 and over	.....	[1] 2	[1] 2	.....	.....	.....	.....	.....	.....
Total	101	140	241	93	171	264	201	77	278

[1] One of these 45 inches in diameter.

Tapped trees on areas A, B, and C: Black jack, 395; yellow pine, 388; total, 783.

WEATHER CONDITIONS.

Table 2 shows the weather conditions throughout the Arizona experiments:

TABLE 2.—*Meteorological record, Fort Valley (Ariz.) experiment station, 1911.*

Month.	Temperature.			Precipitation.		Relative humidity.		
	Mean.	Maximum.	Minimum.	Rain.	Snow.	Mean.	Maximum.	Minimum.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Per cent.*	*Per cent.*	*Per cent.*
April	39.9	65.0	17.9	0.22	Trace.	51	90	20
May	47.9	72.2	21.9	Trace.	.....	46	70	21
June	56.4	83.1	26.3	.22	.....	40	74	16
July	60.7	83.8	30.4	5.71	.....	69	97	26
August	61.4	84.9	41.2	2.76	.....	59	92	25
September	56.8	79.2	34.5	3.47	.....	61	100	20
October	44.7	70.3	12.6	2.68	.....	54	100	17
Nov. 1–15	35.9	51.0	20.5	.22	Trace.	.....	.....	.....

The month of August shows the highest mean temperature (61.4° F.) and, as would be expected, the greatest yield of dip was during this month (see Table 3). Hardly any rain fell until July, when 5.71 inches was recorded. The three following months also had a substantial rainfall. The total precipitation from April 1 to November 15, 15.28 inches, was above the average for previous years. The mean humidity was greatest in July, and the driest weather in June. The mean temperature, humidity, and rainfall during the experiments were all below the average of similar observations made in Florida in connection with experiments there. In that part of Arizona in which the experiments were conducted the diurnal range of temperatures is much greater than in the turpentine regions of the Southeast, and a drop of from 35 to 40 degrees during the night is not at all uncommon. These conditions cause the gum to harden on the faces at night, and it takes a comparatively long period under the influence of the morning sun to start the flow again.

METHOD OF CONDUCTING EXPERIMENTS.

All trees of 12 inches or more breast-high diameter were tapped, except where they were so defective that they would not be used in a commercial operation. No cups were placed on trees less than 12 inches in diameter. One cup was placed on trees between 12 and 15 inches in diameter; two cups on trees between 15 and 24 inches; and three cups on trees more than 24 inches in diameter; but not more than three cups were hung on any one tree, no matter how large. On the other hand, less than the prescribed number of cups were hung in some cases because of defects in the tree.

The cups were of galvanized iron. In hanging them, the rough outer bark near the base of the tree was first smoothed off, and a concave-edged broadax was then driven in with a maul in order to make an incision for a galvanized-iron "apron." The apron was pushed tightly into the incision and the cup held below it by a nail driven into the tree, on which the weight of the cup rested. Plate II shows a "face" at the end of the season. The trees were chipped once a week with an ordinary turpentine "hack." An experienced turpentine hand from the Southeast was employed to do the chipping. While it was the intention to make the streaks one-half inch deep and to add one-half inch to the height of the face at each chipping, measurements taken at the end of the season showed the average depth of the streaks to be 0.68 inch and the average height 0.77 inch. This excess over the measurements originally planned was due to the fact that the workman had been trained to make a much wider and deeper cut. The cups were dipped every three weeks. Eight dippings were made on each area, the first on May 30, three weeks after the first streak was put on, and the last on October 31.

TURPENTINED "FACE" ON WESTERN YELLOW PINE (ARIZONA).

The gum was removed from the cups with a wooden paddle and collected in buckets. Each bucketful was weighed to determine the amount of dip collected.

These details are set forth to show that the experiment was conducted with the idea constantly in mind to make the operations similar to those of the Southeast, so that comparable results might be secured.

YIELDS.

COMPARISON OF YIELDS OF DIP IN ARIZONA AND FLORIDA.

Table 3 shows the weight of crude gum or dip secured from the three experimental areas at the various dippings.

TABLE 3.—*Weight of dip obtained from western yellow pine in Arizona.*

Area A.		Area B.		Area C.	
Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.
1911.	*Pounds.*	1911.	*Pounds.*	1911.	*Pounds.*
May 30	233.75	June 1	151.75	June 6	171.25
June 20	397.75	June 22	320.50	June 27	323.50
July 11	435.75	July 13	407.00	July 18	366.50
Aug. 1	388.75	Aug. 3	372.50	Aug. 8	400.75
Aug. 22	465.25	Aug. 24	406.00	Aug. 29	417.50
Sept. 12	389.25	Sept. 16	362.25	Sept. 19	345.75
Oct. 3	335.75	Oct. 5	299.00	Oct. 10	255.00
Oct. 24	316.25	Oct. 26	205.25	Oct. 31	151.50
Total	2,862.50	Total	2,524.25	Total	2,431.75
Average per cup per week	.238	Average per cup per week	.210	Average per cup per week	.203

Total weight of dip, all areas, pounds, 7,817.50.
Average weight of dip per cup per week, pound, 0.217
Each area of 500 cups chipped 24 times.

There was a total yield of 7,817.5 pounds of gum for the three areas combined (1,500 cups), or an average flow of 0.217 pound per cup per week. Experiments conducted by the Forest Service in Florida show the following yields of crude gum and scrape for the virgin crops:

TABLE 4.—*Weight of dip and scrape obtained from southern yellow pine in Florida, 1905.*

Crop designation.	Weight of dip.	Average weight of dip per cup per week.	Weight of scrape.
	Pounds.	*Pounds.*	*Pounds.*
A	63,615.5	0.256	9,570
B	61,161.5	.246	7,650
C	62,587.0	.252	7,245
D	73,703.5	.297	8,888
Average	65,266.9	.263	8,338

Each crop 8,000 cups, chipped 31 times.

The average yield of dip from the four crops of 8,000 cups each was 65,267 pounds, or 0.263 pound per cup per week. This makes the yield from western yellow pine 82.5 per cent of that obtained from southern yellow pine. In making this comparison the same unit of time is used in both cases, that is, the flow per cup per week. In order that the yield per crop from Arizona and Florida may be on a comparable basis the Arizona yield of 7,817.5 pounds from 1,500 cups may be expressed as the equivalent of a crop of 8,000 cups or 41,700 pounds. This is 64 per cent of the average yield secured in the Florida experiments during the season of 1905. In the Arizona experiments the first chipping was done May 8 and the last dipping made October 31. Had the cups arrived earlier they could have been hung in April and the season lengthened to 26 weeks instead of 24.

COMPARISON OF YIELDS OF SCRAPE IN ARIZONA AND FLORIDA.

Table 5 shows the amount of scrape collected from the experimental areas and the percentage of faces bearing scrape in sufficient quantity to collect.

TABLE 5.—*Scrape obtained from western yellow pine in Arizona.*

Area.	Weight of scrape.	Faces bearing scrape.
	Pounds.	*Per cent.*
A	523.75	87
B	314.75	55
C	288.25	56
All areas	1,126.75	66

Of the 1,500 faces on the three experimental areas 990 had sufficient scrape on them to warrant removing it. The total yield of 1,126.75 pounds of scrape from 1,500 faces chipped 24 times is equivalent to an average yield of 0.031 pounds per face per week. Reduced to a common basis the Florida experiments (see Table 4) show a yield of 0.034 pound of scrape per face per week. Hence the average production of scrape per face in the Arizona experiments was 91 per cent of that in the Florida experiments, if the yields are compared for equal periods of time.

The total yield of 1,126.75 pounds of scrape from 1,500 faces is equivalent to a yield of 6,014 pounds of scrape from a crop of 8,000 faces. Table 4 shows that the weight of scrape obtained in the Florida experiments averages 8,338 pounds per crop of 8,000 faces. The yield from western yellow pine is therefore 72 per cent of that obtained from southern yellow pine when the comparison is made on the basis of the whole season.

Area A produced considerably more scrape than areas B or C. This is accounted for in part by the fact that about one-third of the faces on A were worked for six weeks in the preceding year (1910).

COMPARISON OF YIELDS OF DIP AND SCRAPE FROM BLACK JACK AND YELLOW PINE.

The yields of dip and scrape from both black jack and yellow pine are shown in Table 6:

TABLE 6.—*Weight of dip and scrape obtained from black jack and yellow pine.*

BLACK JACK.

Area.	Number of cups.	Weight of dip.		Weight of scrape.	
		Total.	Per cup per week.	Total.	Per face.
		Pounds.	*Pound.*	*Pounds.*	*Pounds.*
A	175	1,063.5	0.253	211.50	1.21
B	140	754.0	.224	89.75	.641
C	332	1,535.0	.193	192.00	.578
All areas	647	3,352.5	.216	493.25	.762

YELLOW PINE.

A	325	1,799.00	0.231	312.25	0.961
B	360	1,770.25	.205	225.00	.625
C	168	896.75	.222	96.25	.573
All areas	853	4,466.00	.218	633.50	.742

On areas A and B the black jacks gave a larger flow per cup than the yellow pines, while on C this was reversed. But including all trees of both classes the average yield per cup was practically the same. The production of scrape on area A was considerably larger per face for black jack than for yellow pine; on B and C the production per face was about the same for both classes of timber; taking all areas, therefore, the production of scrape ran slightly higher for black jack than for yellow pine.

COMPOSITION OF DIP.

The results of 22 analyses of samples of crude gum are shown in Table 7. These analyses show only the proportions of volatile oil, rosin, water, and chips in the crude gum. Ordinary turpentine from the southern yellow pines consists almost entirely of pinene. A further analysis [1] of the volatile oil from gum obtained in Arizona shows it to be mostly pinene with a small proportion of a higher boiling terpene not found in ordinary turpentine. There is no apparent reason why Arizona turpentine can not be used commercially with entire satisfaction. The same is true of the Arizona rosin.

[1] Forest Service Bulletin 119, An Examination of the Oleoresins of Some Western Pines, by A. W. Schorger.

Considering the pure dip, free from water and chips, there is little variation in the proportions of rosin and turpentine. The average of all the samples, 77.9 per cent rosin and 22.1 per cent turpentine, is practically the same as that of a number of samples of dip from southern yellow pine. The proportion of water and chips in the Arizona dip is considerably lower than in samples of dip collected from turpentine operations in the Southeast. This is to be expected, because in the Southeast the chipping is done as piecework, and the chipper in his hurry frequently neglects to place a guard over the cups, even when he is required to use a guard, which is but seldom. The comparatively few cups hung in Arizona enabled the work to be carefully supervised. Table 7 indicates a slightly higher proportion of turpentine during the beginning and latter part of the season than in the summer months. There is practically no difference in the proportions of rosin and turpentine in gum from black jack and yellow pine.

TABLE 7.—*Results of laboratory analyses on samples of dip from western yellow pine, Arizona.*

Area from which sample was taken.	Date of collection.	Class of timber.	Analysis of samples.					
			As taken.				Free from water and chips.	
			Water.	Chips.	Rosin.	Turpentine.	Rosin.	Turpentine.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A	May 30	Yellow pine.	1.0	2.2	73.9	22.9	76.3	23.7
A	July 11	.....do.....	3.5	3.9	71.7	20.9	77.4	22.6
A	Aug. 22	.....do.....	3.8	0.2	75.3	20.7	78.4	21.6
A	Oct. 3	.....do.....	5.7	0.6	71.8	21.9	76.6	23.4
A	June 20	Black jack..	2.3	0.8	73.4	23.5	75.8	24.2
A	Aug. 1	.....do.....	9.5	1.4	67.1	22.0	75.3	24.7
A	Sept. 12	.....do.....	4.9	0.3	74.7	20.1	78.8	21.2
A	Oct. 24	.....do.....	3.4	0.2	70.2	26.2	72.8	27.2
B	June 22	Yellow pine.	2.0	3.1	74.4	20.5	78.7	21.3
B	Aug. 3	.....do.....	5.0	2.2	75.6	17.2	81.5	18.5
B	Sept. 16	.....do.....	5.1	1.7	74.0	19.2	79.4	20.6
B	Oct. 26	.....do.....	4.4	1.0	71.5	23.1	75.6	24.4
B	June 1	Black jack..	1.9	2.8	73.9	21.4	77.5	22.5
B	July 13	.....do.....	3.7	2.0	75.8	18.5	80.4	19.6
B	Aug. 24	.....do.....	3.5	1.3	75.6	19.2	79.8	20.2
B	Oct. 5	.....do.....	4.3	1.5	73.4	20.8	77.9	22.1
C	June 6	Yellow pine.	1.1	0.9	75.3	22.7	76.8	23.2
C	Aug. 8	.....do.....	1.7	0.6	79.9	17.8	81.7	18.3
C	Oct. 10	.....do.....	6.2	0.8	72.7	20.3	78.2	21.8
C	June 6	Black jack..	1.3	1.7	75.6	21.4	77.9	22.1
C	Aug. 8	.....do.....	4.9	0.2	75.3	19.6	79.3	20.7
C	Oct. 10	.....do.....	6.0	0.7	72.8	20.5	78.0	22.0
Average of all samples..	.....	.....	3.9	1.37	73.8	20.9	77.9	22.1

CONDITION OF TAPPED TREES.

At the time the cups were hung, the trees were examined at the butt to determine if they were infested with boring beetles. Very few of the trees showed signs of insect attack, but, because of the thick, rough bark the examination told but little, since the evidences of beetle infestation are not noticeable except in severe cases. At the

conclusion of the experiment also the faces on a number of trees on each area were examined. Of 276 trees inspected, the faces on 116 showed indications of borers. These indications, consisting of small deposits of finely divided wood, were generally found on the lower part of the face near the apron at the junction of the inner bark and sapwood. Whether or not the trees were infested with borers before the cups were hung is not known. It was noted that practically all the trees which showed signs of borers also contained holes made by woodpeckers, doubtless in search of the insects.

Of 634 faces examined on the three areas 5 were found to be dry and 26 partially dry.

EVAPORATION FROM CUPS.

The rate of evaporation from the cups was determined by exposing cups half full of fresh gum to the action of the air and weighing them at regular intervals. The samples of gum were secured by taking small amounts from as many of the cups as necessary on the first or second day after a fresh streak had been put on. Two samples were taken from each area after each dipping. As dip is collected every three or four weeks in commercial operations, the loss in weight during the first four weeks is the significant figure in the evaporation tests. Forty-eight evaporation samples were used. Of these, 14 showed no loss at all in weight for the first four weeks; the remaining 34 samples showed losses ranging from 1.5 to 10.5 per cent of the original weight. The average loss in weight for all the samples was 3 per cent. The gum as exposed contained turpentine, rosin, water, and chips. The loss by evaporation was, of course, made up of turpentine and water. The average loss of turpentine by evaporation from the cups in the Arizona experiments was therefore less than 3 per cent. No evaporation figures are available for southeastern operations.

SPECIAL PROBLEMS INVESTIGATED.

Area D contained 50 selected trees 15 inches or more in diameter breast high. Two cups were hung on each tree—one on the north side and one on the south side. In 25 of the trees the first streak was put on so as to bring the peak of the face 3 inches above the apron. In the remaining 25 trees the first streak was put on so as to bring the peak 18 inches above the apron. Of the 50 selected trees about half were black jack and half yellow pine. The 3-inch and 18-inch faces were placed on black jack and yellow pines in about equal proportions. The rough outer bark between the peak and the apron was smoothed off in all of the trees. The trees were chipped every week in the ordinary manner. The cups were dipped every week and weighed on the third, fifth, and seventh day after each chipping throughout the season by means of a small portable balance. The dip from the

low and high faces was kept separate and typical samples chosen for analysis.

COMPARISON OF YIELDS FROM NORTH AND SOUTH FACES.

The total yield for the 50 cups on the north side of the trees from the first dipping on June 3 to the last dipping on November 3 was 242.6 pounds and for the south cups 266.2 pounds. These weights show a 9 per cent greater flow on the south side of the trees than on the north. Figure 2 shows the average yield per week for both the north and south faces of each of the 50 trees arranged in order of the yields from the south faces. Twenty-seven south cups yielded more than the corresponding north cups, while 17 north cups showed an excess over the corresponding south cups. The remaining six trees had about the same flow for both cups. The diagram shows

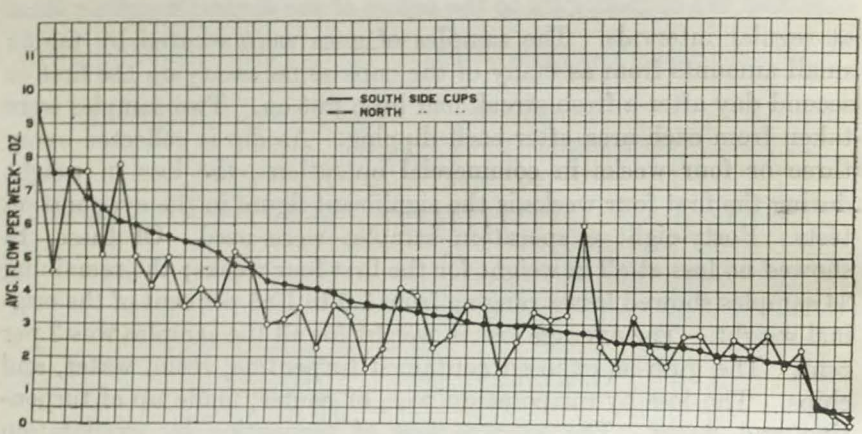


FIG. 2.—Comparison of flow from north and south faces of each of fifty trees.

the tendency of faces on the same tree to give the same yields. Trees having an exceptionally good or exceptionally poor flow generally show it in both faces.

COMPARISON OF DIP FROM HIGH AND LOW FACES.

While there was an attempt to determine what greater loss there would be, if any, from evaporation from the higher faces, it was found to be impossible to select trees with comparable flows. As far as it was possible to carry out the experiment, the indications were that the proportions of rosin and turpentine in the dip were not affected by the height of the face, and this would seem to show that there was no appreciable difference of evaporation on faces with a difference in height of 15 inches. Table 8 gives the composition of dip from the two heights of faces. The results of the analyses given in this table are very similar to those given in Table 7.

TABLE 8.—*Composition of dip from 3-inch and 18-inch faces.*

Date of collection.	3-inch faces.		18-inch faces.	
	Rosin.	Turpentine.	Rosin.	Turpentine.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
June 10	78.9	21.1	78.2	21.8
July 21	76.5	23.5	78.4	21.6
	80.0	20.0	79.2	20.8
	78.7	21.3	78.5	21.5
Sept. 1	80.0	20.0	78.6	21.4
	78.4	21.6	78.9	21.1
Oct. 13	78.3	21.7	77.0	23.0
	77.0	23.0	78.3	21.7
Average	78.5	21.5	78.4	21.6

EFFECT OF TEMPERATURE ON WEEKLY FLOW.

Figure 3 shows the average flow per cup for the 50 trees on area D for each week and the corresponding average temperature. The

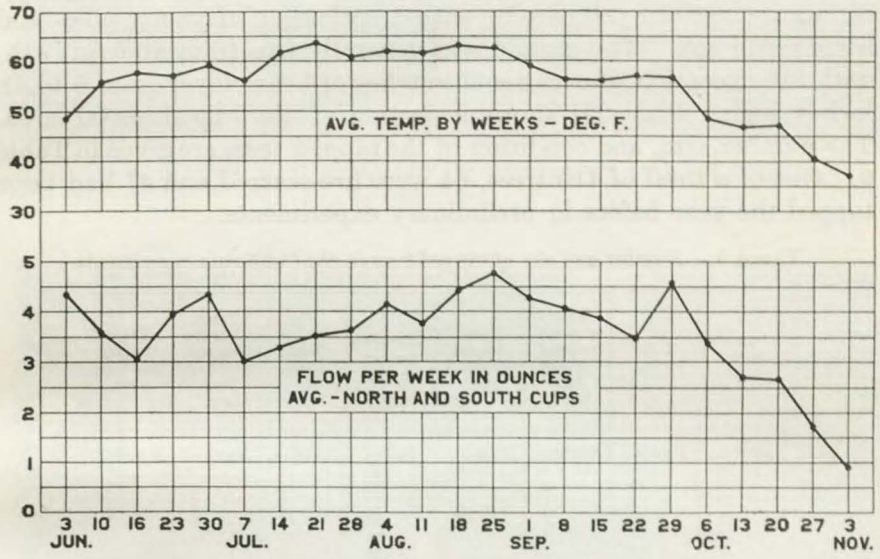


FIG. 3.—Relation between temperature and rate of flow of gum.

flow increased or decreased with increase or decrease of temperature with few exceptions. The effect of cool weather in checking the flow is especially marked toward the end of the season.

RATE OF FLOW DURING WEEK.

It is well known that gum flows most rapidly just after a fresh streak and that the rate of flow decreases until at the end of a week it has become so slow as to necessitate rechipping. Data on the variation in rate of flow were secured by weighing the north and south cups on 10 trees on the third day after each chipping throughout the season. The sum of the weights for each tree was compared with

the weight of the total flow for the season from the same trees. An average of the results shows that 73 per cent of the weekly flow occurred in the first three days. This ratio varied from 65 per cent to 78.6 per cent in the 10 test trees.

CALIFORNIA EXPERIMENTS ON WESTERN YELLOW PINE.

(Pinus ponderosa.)

DESCRIPTION OF AREA AND METHOD OF EXPERIMENT.

The California turpentine experiments on western yellow pine were conducted on the Sierra National Forest about 2 miles from North Fork, Madera County. Nine hundred and sixty-eight cups were hung on about 160 acres, which included several ridges extending from a main ridge, and ranged between 3,500 and 4,500 feet in elevation. No cups were hung on the few trees in the small canyons between the ridges, and a few large trees with extra thick bark also were left out. The stand was very open, and consisted principally of mature western yellow pine with a sprinkling of young pines and some scrub oak. The ground was generally free from undergrowth, with the exception of occasional patches of bear clover from 6 to 18 inches high. Plate III shows a portion of the experimental area. The number, size, and condition of the tapped trees are given in Table 9. Out of a total of 410 trees, 64 were fire-scarred and 47 had been tapped the year before in preliminary experiments.

TABLE 9.—*Number and size of tapped trees in the California experiments.*

Diameter breast high.	Total trees.	Trees with fire-scarred butt or "cat face."	Trees tapped previous year.	Diameter breast high.	Total trees.	Trees with fire-scarred butt or "cat face."	Trees tapped previous year.
Inches.	*Number.*	*Number.*	*Number.*	*Inches.*	*Number.*	*Number.*	*Number.*
12	8	3	2	29	13	.....	.....
13	10	3	.....	30	16	1	2
14	15	1	1	31	13	3	1
15	10	2	2	32	11	2	1
16	20	4	1	33	12	2	.....
17	13	2	.....	34	6	1	.....
18	21	1	4	35	7	2	.....
19	20	4	.....	36	4	0	.....
20	29	4	1	37	2	1	.....
21	22	3	6	38	.....	.....	.....
22	25	3	2	39	1	.....	.....
23	19	3	2	40	2	1	.....
24	34	6	10	41	.....	.....	.....
25	29	4	5	42	.....	.....	.....
26	18	4	4	43	2	0	.....
27	12	1	2				
28	16	3	1	Total..	410	64	47

The same procedure in hanging the cups and chipping was followed as in the Arizona experiments, except that the chipping was done by forest rangers and guards instead of by an experienced turpentine hand. The first streak was put on July 7 and the last dipping made November 1; during this period of approximately 16 weeks the trees were chipped 16 times and dipped 8 times.

FIG. 1.—TYPICAL WESTERN YELLOW PINE TURPENTINE AREA IN CALIFORNIA.

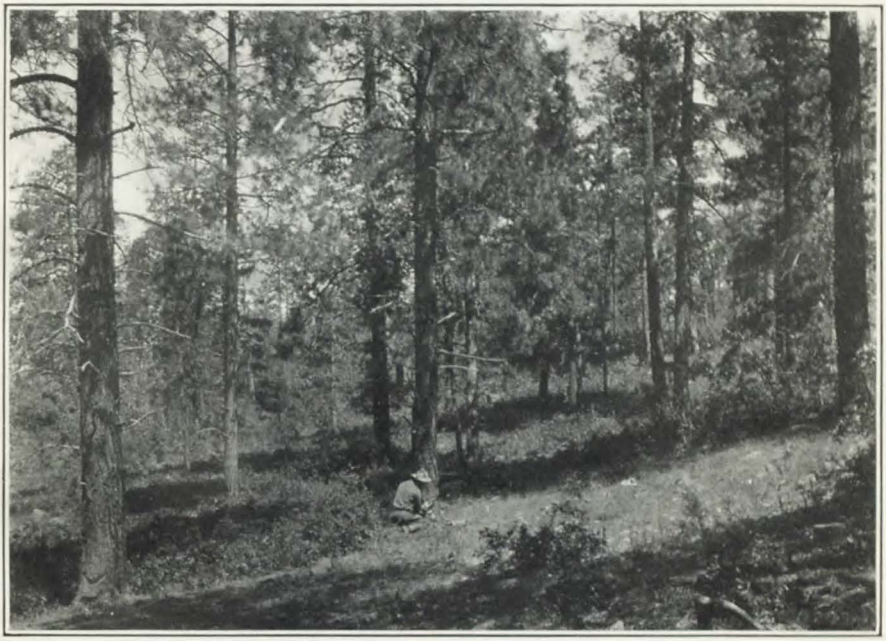


FIG. 2.—TYPICAL WESTERN YELLOW PINE TURPENTINE AREA IN COLORADO.

WEATHER CONDITIONS.

Table 10 shows the weather conditions during the California experiments, including three months preceding and one month following. The mean temperature on the area from June 1 to November 30 was a few degrees lower than the mean temperature recorded for the Florida [1] experiments from March 17 to November 2. The diurnal range is much greater than in Florida. The total rainfall on the California area for the period of the experiments amounted to only 2.16 inches.

TABLE 10.—*Meteorological record, Northfork (California) ranger station, 1911.*

Month.	Temperature.				Precipitation.	
	Mean.	Maximum.	Minimum.	Average range during 24 hours.	Rain.	Snow.
	°F.	°F.	°F.	°F.	*Inches.*	*Inch.*
March	50.1	84	30	25	12.44	0
April	50.2	79	30	29	4.25	0
May	56.3	87	32	34	1.18	0
June	66.8	103	46	37	Trace.	0
July	79.5	108	52	39	0	0
August	72.5	101	50	39	0	0
September	63.7	98	42	39	.35	0
October	61.2	94	32	43	.3	0
November	54.0	90	24	45	1.51	0
December	41.5	76	15	29	1.58	0

YIELDS.

Table 11 shows the weights of gum secured from the area at the various dippings. The average yield of 0.281 pound per cup per week is slightly greater than that in the Florida experiments (0.263 pound; see p. 9), but it should be kept in mind that the California experiments were not begun until July and that had they been started earlier in the season this average might have been lower. Seventeen faces were chipped at monthly intervals during December, January, and February. A yield of 16 pounds of dip was obtained, which shows that gum continues to flow throughout the winter.

TABLE 11.—*Weight of dip obtained from western yellow pine in California (968 cups).*

Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.
	Pounds.		*Pounds.*
July 18	630	Oct. 19	578
July 18	384	Nov. 1	490
Aug. 16	702		
Sept. 5	610	Total	4,366
Sept. 15	418	Average per cup per week	0.281
Sept. 27	554		

[1] Forest Service Bulletin 40, A New Method of Turpentine Orcharding, by Charles H. Herty.

The total weight of scrape obtained from the area at the end of the season amounted to 287 pounds. This is equivalent to a yield of 0.018 pound of scrape per face per week, somewhat less than obtained in the Florida experiments (see Table 4).

COMPOSITION OF DIP AND SCRAPE.

The results of analyses of two samples of crude gum and one sample of scrape are given in Table 12. The proportion of turpentine in the California gum, as shown by these samples, is less than in the Arizona gum (see Table 7). A further analysis of the volatile oil from California western yellow pine shows that it contains a considerably smaller proportion of pinene than ordinary turpentine, and contains another oil not found in ordinary turpentine. It is, however, probable that turpentine from California western yellow pine will prove of commercial value. Its use is recorded in California at the close of the Civil War, when turpentine operations in the Southeast were practically at a standstill. The operations in California were very crude, however, and were discontinued as soon as naval stores from the Southeast became available.

TABLE 12.—*Results of laboratory analyses on samples of dip and scrape from western yellow pine, California.*

Material.	Date of collection.	Composition of samples.					
		As taken.				Free from water and chips.	
		Water.	Chips.	Rosin.	Turpentine.	Rosin.	Turpentine.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dip	Oct., 1910	1.2	0.8	79.5	18.5	81.1	18.8
Do	Oct., 1911	1.0	1.6	81.1	16.3	83.2	16.7
Scrape	Oct., 1910	1.1	.8	84.9	13.2	86.4	13.4

EVAPORATION FROM CUPS.

The loss from the cups by evaporation was tested by weighing four cups approximately half full of fresh gum on September 7 and again on December 1. The average loss in weight was 2.8 per cent.

COLORADO EXPERIMENTS ON PIÑON.

(*Pinus edulis.*)

DESCRIPTION OF AREA AND METHOD OF EXPERIMENT.

The turpentine experiments on piñon were conducted on the Montezuma National Forest. The cups were placed on a tract 2½ miles southeast of Mancos, representative of average conditions in the piñon stands of southwestern Colorado. The elevation is 7,200 feet; the surface is rolling with a gentle slope to the southwest;

the soil is adobe, very thin, and underlaid by the Mancos shales. The trees were of various sizes; those of medium size generally occurred in groups, while the old trees usually stood alone. There was heavy underbrush, which made the work of placing the cups very difficult. The many defects in the trees, such as gnarled, twisted, and partially dead butts, and low limbs, further complicated the problem. It was necessary to place some of the cups 2 or 3 feet from the ground because of these conditions. One hundred and twenty-three cups were hung on 4 acres, approximately 31 cups to the acre. Ninety-five trees were tapped; of these 67 had 1 cup and 28 had 2 cups. The diameter of the tapped trees ranged from 7 to 26 inches about 1 foot above the ground. Plate IV shows a single piñon on the edge of the experimental area.

The method of placing the cups was the same as in the Arizona experiments, except that no attempt was made to limit the minimum diameter of tapped trees or the number of cups placed on any one tree. The chipping was done by a ranger who soon became accustomed to handling a hack.

WEATHER CONDITIONS.

Table 13 shows the weather conditions at Mancos while the turpentine experiment was in progress. Mancos is at approximately the same elevation as the piñon area.

TABLE 13.—*Weather record at Mancos, Colo., June to October, 1911 (U. S. Weather Bureau).*

Month.	Temperature.		Precipitation.
	Maximum.	Minimum.	
	°F.	°F.	*Inches.*
June	86	33	1.92
July	83	43	5.39
August	88	38	1.82
September	83	36	3.32
October	68	14	3.63

YIELD.

The weight of dip secured from the piñon area at the various dippings is shown in Table 14.

TABLE 14.—*Weight of dip obtained from piñon pine in Colorado (123 cups).*

Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.
	Pounds.		*Pounds.*
June 30	25.0	October 13	50.0
July 21	50.0	October 31	12.0
August 11	71.0		
September 1	75.0	Total	366.5
September 22	63.5	Average per cup per week	.147

The total yield of 366.5 pounds represents the dip secured from 123 cups from June 9, when the first streak was put on, to October 31, the date of the last dipping, a period of approximately 20 weeks. The average yield of 0.147 pound per cup per week is about two-thirds as much as secured from western yellow pine in Arizona and a little over half the average yield of southern yellow pine in Florida operations.

COMPOSITION OF DIP.

Table 15 gives the results of analyses on five samples of piñon dip.

TABLE 15.—*Results of laboratory analyses on samples of dip from piñon, Colorado.*

Date of collection.	Rosin.	Turpentine.
	Per cent.	*Per cent.*
June 30	81.3	13.7
July 15	78.3	21.7
Aug. 11	81.0	19.0
Sept. 1	78.3	21.7
Sept. 23	78.0	22.0
Average	78.4	20.6

NOTE.—Per cents of rosin and turpentine are calculated for gum free from water and chips.

The proportion of turpentine in the piñon gum was slightly less than in the gum from Arizona western yellow pine (see Table 7). The turpentine from piñon is composed mainly of pinene and in this respect is similar to turpentine from southeastern pines, but it also contains another oil of quite different physical properties. The turpentine, however, could probably be used for industrial purposes.

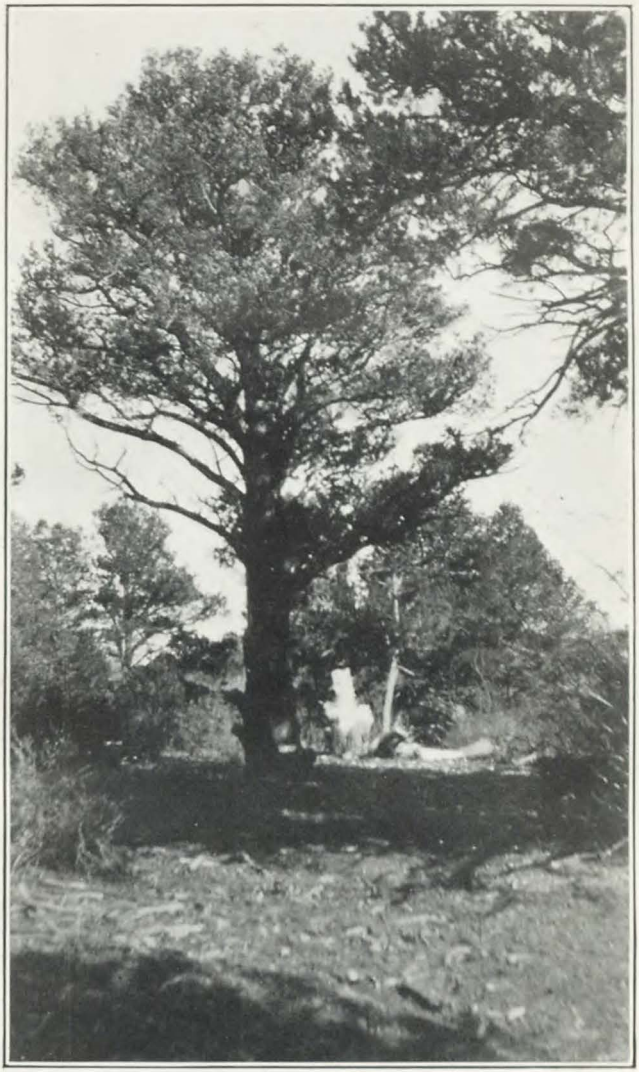
COLORADO EXPERIMENTS ON WESTERN YELLOW PINE.

(*Pinus ponderosa* var. *scopulorum*.)

DESCRIPTION OF EXPERIMENTAL AREAS.

The turpentine experiments on western yellow pine in Colorado were conducted on two areas, one on the Montezuma National Forest and the other on the San Juan. The Montezuma area is about 7 miles from Mancos, on a southwestern slope at an elevation of about 7,800 feet. The area was lightly cut over several years ago, and some of the largest trees were removed; but it still contains trees of all ages and is a representative stand for the locality. The soil is thin and rocky. One hundred and twenty-five cups were hung on an area of 6 acres. Sixty-eight trees were tapped, ranging from 13 to 32 inches in diameter breast high. The first streak was put on June 10.

The San Juan area is about 6 miles north of Durango on a fairly steep slope at an elevation of about 7,500 feet. The area contained considerable undergrowth. Plate III, fig. 2, shows a typical view on the San Juan area. One hundred and twenty-five cups were hung on 62



MATURE ISOLATED PIÑON ON TURPENTINED AREA IN COLORADO.

trees, ranging in size from 14 to 42 inches diameter breast high. Because of adverse weather conditions, weekly chippings were skipped three times during the course of the experiment, so that instead of 21 chippings from June 16 to November 4 there were but 18. Considerable rain fell while the experiment was in progress. In Durango, which is some 2,500 feet lower than the turpentine area, the precipitation from June 1 to October 31 was 17.08 inches. The greater elevation and the topographic features of the experimental area tend to cause a much greater precipitation there than in Durango. During the last few weeks of the experiment there were several snow flurries and periods of cold weather with freezing at night.

The method of hanging the cups and conducting the work on both areas was the same as in the Arizona experiments, except that the chipping was done by rangers. The trees used in the Colorado and Arizona experiments were of the same species and variety.

YIELDS.

Table 16 shows the weights of dip obtained from western yellow pine on the Montezuma and San Juan areas.

TABLE 16.—*Weights of dip obtained from western yellow pine in Colorado.*

Montezuma area.		San Juan area.	
Date of dipping.	Weight of dip.	Date of dipping.	Weight of dip.
	Pounds.		*Pounds.*
July 2	52.75	July 8	34.75
July 24	68.5	July 29	58.5
Aug. 12	89.0	Aug. 19	75.0
Sept. 2	87.0	Sept. 9	66.75
Sept. 23	79.0	Oct. 8	55.75
Oct. 14	75.0	Nov. 4	27.5
Nov. 1	18.0		
Total	469.25	Total	318.25
Average per week per cup	.188	Average per week per cup	.127

The average flow per cup per week on the Montezuma area was 0.188 pound, and on the San Juan 0.127 pound; in both cases lower than the average of 0.217 pound secured from the same pine in the Arizona experiments. This difference is perhaps due in part to the fact that the chipping in Arizona was done by an experienced turpentine hand. On the Montezuma area the greater regularity in carrying on the experiment accounts, at least partly, for the higher yield as compared with that from the San Juan area.

SUMMARY OF RESULTS.

The Arizona experiments show a yield of resin from western yellow pine (*Pinus ponderosa scopulorum*) about four-fifths as great as that obtained from southern yellow pines (*Pinus palustris* and *Pinus*

heterophylla) in average operations in Florida [1] if the comparison is based on the same period of time for both. Weather conditions in Arizona, however, will allow only a 24 or possibly a 26 weeks' season as against a 30 or 35 weeks' season in the Southeast, so that when the yields for an entire season are compared, western yellow pine shows a production about two-thirds as great as that from southern yellow pine. The average proportions of rosin and turpentine in the gum were about the same as in gum from the southeastern pines, and the turpentine had a composition much like that from the Southeast.

The California experiments on western yellow pine, carried on over a period of 16 weeks from July 7 to November 1, show an average rate of flow slightly greater than that in the Florida experiments. Had the work in California been started earlier, it is probable that the weekly average would have been lower, as a smaller yield is to be expected early in the season. The season of flow in California will undoubtedly be as long as in Arizona, and probably longer. The composition of the volatile oil obtained by distilling the gum from California differs from that of ordinary turpentine somewhat more than does the Arizona turpentine, but the oil probably will be satisfactory for industrial purposes.

Piñon (*Pinus edulis*) in Colorado had a rate of flow slightly over half that of the Florida pines for a 20-weeks period, from June 9 to October 31. The volatile oil from the piñon gum differs somewhat from ordinary turpentine, but is probably suited to industrial use.

PROBLEMS WHICH CONFRONT COMMERCIAL DEVELOPMENT.

In considering the possibilities of commercial turpentine operations on western pines the problem of labor is one of the first that presents itself. In Arizona, Mexicans constitute a large part of the laboring class, but they are totally unfamiliar with turpentine work. Negro turpentine hands could be brought in from the Southeast, but their transportation would be costly. A few negro hands might be secured to teach the Mexicans, but whether the results would be satisfactory is, of course, unknown. In California both Indian and white labor is available in many timbered portions that have turpentine possibilities; here also the chippers would have to be taught how to use a hack.

The shorter season in Arizona, as compared with that of the Southeast, and the comparative severity of the winters in the timbered parts of the State might make it necessary to discontinue operations entirely for a few months during the winter. This would necessitate the

[1] As a basis of comparison for the yields obtained in the West, the results of experiments made by the Forest Service in Florida several years ago are used. (See Bulletin 90, Relation of Light Chipping to the Commercial Yield of Naval Stores, by Charles H. Herty.)

reorganization of the operating force each spring, with a great many attendant difficulties. The California experiments were not started until June, so that the time when the gum begins to flow is not yet known. The flow continued in California longer than in Arizona. Temperature records taken on the California and the Arizona areas show a considerably higher average temperature in California. The diurnal range of temperature is greater in California than in Arizona.

Western yellow pine timber generally grows in open stands free from underbrush. In the majority of stands there would be but little, if any, more difficulty in moving the crude gum than in the Southeast. On rough ground burro pack trains might be used. Two small kegs or buckets holding about 150 pounds of dip could be slung on each animal.

The number of cups that can be hung on an acre of average western yellow pine compares favorably with many areas that are now being turpentined in the Southeast. The western trees are larger than most of the southeastern ones. The bark of the western pines is, however, thicker and rougher, and it will be necessary to remove the outer bark before hanging cups or chipping the trees; and this, of course, means the expense of an extra step not necessary in southeastern operations. Such work can be done by the use of a broad ax or heavy spade-shaped tool with a cutting edge.

The cost of securing turpentine rights in the Southeast is constantly rising, and it is likely that turpentine stumpage could be leased at lower rates in the West.

At present the turpentine and rosin used in the West is shipped from the Gulf States. The advantage of cutting out a two or three thousand mile haul to western markets is evident.

The commercial success of turpentine operations in the Southwest will be doubtful until they have been tried on a commercial scale. Nearly as much turpentine and rosin was obtained from western yellow pine, and the amount of timber available for turpentine operations in the Southeast is constantly diminishing. These two facts make it reasonable to suppose that turpentine operations in the large tracts of virgin pine timber of the West will, in time, be justified.

○